The relationship between dynamic price and dynamic unemployment: the case of the Central European-3 and the Baltic Tigers

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ABSTRACT

Convention specifies the relationship between price and unemployment in terms of the Phillips curve (PC) where inflation and the rate of unemployment are correlated. This paper uses a variant of the PC that is more consistent with the relationship between price and output as depicted in the aggregate supply (AS) curve. The relationship between price and unemployment using convention and its variant is tested on Poland, the Czech Republic, Hungary, Estonia, Latvia, Lithuania and the pooled data. The Expectations Augmented (EA) is able to track a negative relation between inflation and unemployment better than the New Keynesian (NK) is able. Within the EA runs, the convention is able to track the same negative relation better than the variant, but one has to be cautious given the implied results.

Keywords: Employment, Unemployment, Inflation, Incomes Policy, Price Policy, Phillips Curve, Central Europe, Baltic Tigers.

JEL Classification codes: E24, E31, E64

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Introduction

Convention specifies the relationship between price and unemployment in terms of the Phillips curve (PC) where inflation and the rate of unemployment are believed to be negatively correlated. However, the relationship is ambiguous when juxtaposed with the relationship between price and output as depicted in the aggregate supply (AS) curve (Dumlao, 2012). In the AS curve, price and output are both expressed in terms of their static levels. But in the PC, price is expressed in its dynamic state and unemployment is expressed in its static state. That is, inflation or the rate of change of price through time is correlated with the rate of unemployment that is captured at a certain time.

A variant specification is where inflation is related with the rate of change of unemployment and employment. As such, the relationship between price and unemployment has stronger theoretical basis in the context that it is directly derived from the AS curve. This paper tests if there is a relationship between price and unemployment using the conventional specification and the variant. The test covers the Central European economies Poland, the Czech Republic and Hungary or the CE-3 and Estonia, Latvia and Lithuania or the Baltic Tigers.

The rest of the paper is organized as follows. The first section is a review of literature. The second section is a theoretical derivation of the variant specification from the AS curve and Rotemberg's (1982) quadratic price adjustment cost model. The third, fourth and fifth sections present the empirical models of the PCs, the data used and the results respectively. The sixth is conclusion.

1. Review of Literature

Going back to *The General Theory of Employment, Interest and Money*, Keynes (1936) describes the AS curve as one that is positively sloped and that the slope is at an increasing rate. Figure 1 shows the AS curve shown in mainstream textbooks like that in Dornbusch, Fischer and Startz (2001, page 89). In 1958, Phillips found and published the empirical relationship between the rate of change of wage with the rate of unemployment in the United Kingdom from 1861 to 1957. Such relation became known as the "wage Phillips curve" (WPC) depicted in Figure 2. As wage level is pegged with the price level, the rate of change of wage must move with the rate of change of price or inflation. Hence, substituting inflation for the rate of change of wage results in Figure 3, that is generally referred in literature as the "Phillips curve" (PC). As in Sleeman (2011), Samuelson and Solow in 1960 christened the Phillips curve and interpreted it as "a potential tradeoff between inflation and unemployment" (page 235).

However, evidence from Phillips' original data (Lipsey, 1960) and evidence from the United States tested in the 1960s proves that the relationship between inflation and unemployment rate is not convincingly consistent with that depicted in Figures 2 and 3 respectively. Such tests imply that there was not one stable PC. Rather, there seems to be many PCs that shift over time as result of some not yet determined factor. In 1968, Friedman established that expectations in inflation cause shifts of the PC thus the expectations augmented PC (EAPC). Where π and π^e are actual and expected inflations respectively, u and

u^N are rates of actual and some "natural" unemployment, and a is some positive parameter; Friedman and Phelps' EAPC is conventionally expressed as:

1. $$\pi = \pi^e - a(u - u^N).$$

Figure 1 - Aggregate Supply (AS) Curve

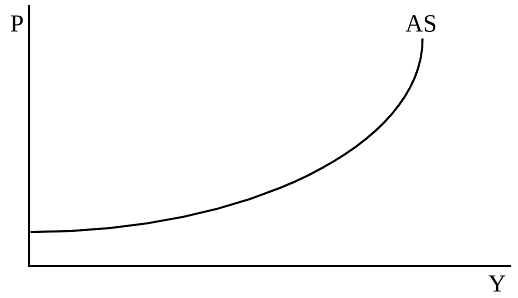


Figure 2 - Wage Phillips Curve (WPC)

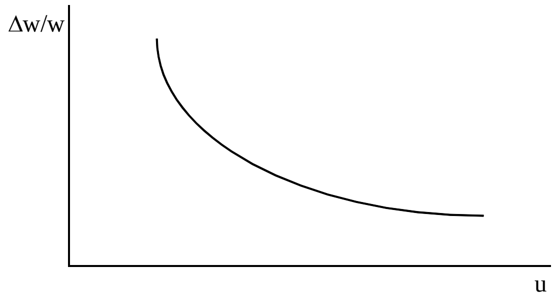
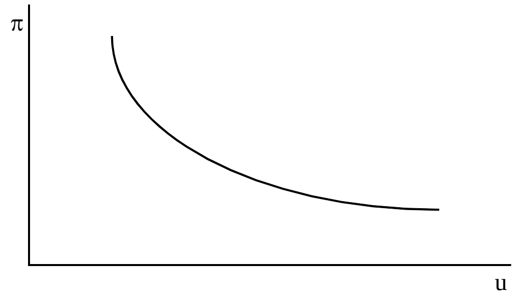


Figure 3 - Phillips Curve (PC)



A different interpretation is that of the New Keynesians following Rotemberg's (1982) quadratic price adjustment cost model, and Calvo's (1983) and Taylor's (1979) staggered contracts model. Where y is log of output and y^N is log of the natural output, Roberts (1995) synthesizes the models to[1]

2. $$\pi_t = E_t \pi_{t+1} + a(y_t - y_t^N).$$

As in Roberts and Blanchard and Gali (2007), the above is commonly referred to as the New Keynesian Phillips Curve (NKPC). Accordingly, inflation is a function of expected future inflation ($E_t\pi_{t+1}$) and not the expected current inflation (π_t^e). Notice the way that expectation is expressed. For a given variable like π, $E_{t-1}\pi_t$ is the expected inflation as of period t-1, π_t^e is the expected inflation as of present ex ante the actual inflation is calculated and published, and π_t (without the superscript e) is the actual inflation that is known ex post it is calculated and published.

[1]The more general notation is $\Delta p_t = c + E_t\Delta p_{t+1} + \gamma y_t + \varepsilon_t$, where p is the log of price level, y is the output gap, c and γ are positive coefficients and ε is the error term. The notation is adjusted for consistency with the rest of the text. The stochastic error term e is also excluded for convenience without loss of generality.

In this framework, prices are sticky because of some lack of fluidity in the micro level like cost of adjustment and firms changing prices on a staggered basis. Taylor (1979) and the Keynesians in general view the labor markets as central to aggregate nominal rigidities. As such, unemployment is viewed as an alternative sometimes even superior indicator of overall economic activity. The practice is to substitute unemployment rate for the output gap. What follows is what this paper will refer to as the NKPC:

3. $\pi_t = E_t\pi_{t+1} + a(u_t - u_t^N).$

Convention presumes that the relationship between price and output conveyed in the AS curve (Figure 1) translates to the relationship between inflation and unemployment conveyed in the PC (Figure 3).The conventional presumption seems straightforwardly logical. First, higher inflation results in higher price level so that it should follow that the vertical axes in both have consistent relationship either with output or with unemployment. Second, higher output results in higher employment so that substituting unemployment rate for output should invert to the curve as it appears going from the AS curve to the PC.

But Dumlao (2012) argues that the convention's presumption from one vertical axis to another and one horizontal axis to another is ambiguous. Accordingly, on the vertical axis, high price level at present resulted from high inflation in the past but it does not necessarily mean that inflation is high at present. Hence a high price at present may coincide with a low inflation at present. On the horizontal axis, any level of output does not necessarily translate to some rate of unemployment. All else being equal, higher levels of output require higher levels of employment. However, the story on the level of employment is distinct from the story of the rate of employment. More so, higher levels of employment result in higher rates of employment only if the increase in the level of employment is greater than the increase in the total labor force.

Also, the treatment of variables in the AS curve is not consistent with that in the PC. In the AS, both price and output are expressed in levels without some reference to some total price and some total output. In the PC, price expressed in inflation is still without reference to some total inflation but suddenly the supposed opposite of output which is unemployment is in reference to some absolute range from zero to 100 percent. More importantly, the inverse relationship between inflation and unemployment rate as shown in the PC is not always true. For example,

> If 3 of 100 people are unemployed and they have no outstanding job offers for some time, they will not as much demand for higher wages so that there will be less wage inflation. Likewise, if employers are satisfied with their workforce such that there is hiring freeze, they will not aggressively look for applicants so as to increase their offer wage and this will cause less wage inflation. If 10 of 100 people are unemployed and have 15 outstanding job offers, they will likely ask prospective employers to bid so as to drive wages higher thus causing wage inflation. Likewise, if employers are aggressively expanding and seeking for additional workers, they will as aggressively increase their offer wage thus causing wage inflation.

Therefore, a lower rate of unemployment can correspond to low inflation and a higher rate of unemployment can correspond to higher inflation.

2. Theoretical Derivation of Variant EAPC and Variant NKPC

a. Aggregate Supply Curve

As in Dumlao (2012), assume that the static level of wage is related with the static level of expected price and static level of unemployment. Where *P* is the price level, *U* is the static level (as opposed to rate) of unemployment and *T* is population of labor force, the relationship may be stated in

4. $$W = \frac{P^e}{U/T}.$$

Note that all variables are expressed in static levels and that all are expressed not in comparison to some benchmark limit; that is there is no totals in wage, price, unemployment and labor force. Assume for simplification that there is only one input and that is labor. Where Y_j and L_j are output and labor employment of firm *j*, *A* is technological parameter and α is labor elasticity, consider the typical production function

5. $$Y_j = AL_j^{\alpha}, \quad 0 < \alpha < 1.$$

Assume perfect competition. Where P_i and W_i are price and wage levels in industry *i*, profit is

6. $$P_iY_j - W_iL_j \quad \therefore \quad P_i\left(AL_j^{\alpha}\right) - W_iL_j.$$

The representative firm cannot affect wage and price but can affect the number of laborers it employs. As such, it is left out in choosing the optimal number of laborers which results in the profit maximizing solution which is:

7. $$\alpha P_iAL_j^{\alpha-1} = W_i \quad \therefore \quad \alpha P_i\frac{Y_j}{L_j} = W_i.$$

Consistent with general practice in Neoclassical and New Keynesian (NK) literature, it is inferred that what happens at the macro level mimics what happens in the micro level. Hence, the macroeconomic outcome is

8. $$\alpha P\frac{Y}{L} = W.$$

Combining equation 4 with the above and then solving for price gives

9. $$P = \frac{1}{\alpha}P^e\left(\frac{T}{Y}\right)\left(\frac{L}{U}\right).$$

The above is this paper's AS curve. Consistent with the standard AS properties as in Figure 1, an increase in expected price raises the price (upward shift of the AS curve). An increase in the labor force (*T*) with proportionate increase in *L* and *U* while keeping the price level constant necessarily means an increase of level of output (*Y*) (rightward shift of the AS). An increase in technology (*A*) increases output (*Y*) and lowers the price (downward shift of the AS curve). An increase in employment (*L*) that in turn decreases unemployment (*U*) increases the price (movement along the AS curve).

b. Rotemberg's quadratic price adjustment cost model

Similar results come out if one uses either that of Rotemberg (1982), Calvo (1983) or Taylor (1979). They all lead to the same basic NKPC as Roberts (1995) shows. This paper arbitrarily picks that of Rotemberg's. In his framework, firms minimize the cost of setting price from some ideal price and the cost of changing price. Suppose that *C* is cost, *P* is the actual price and P^C is the ideal price but with cost to adjustment, and their lower case being their respective natural logs. The quadratic price adjustment function is

10. $$c_t = E_t \sum_{t=0}^{\infty} (p_t - p_t^C)^2 + (p_t - p_{t-1})^2.$$

Because there is cost to adjusting prices, the firm is forced to charge at a price of *p* instead of p^C, so that p_t-p_t^C is the cost of the price being different from some ideal price. On the other hand, p_t-p_{t-1} is the cost of adjusting the price. The usual formulation includes a discount factor such as that used by Roberts; for simplification without losing generality, the factor is excluded here.

Where P^M is the average price of the rest of the market or the firm's competitors and Y^N is the trended output, similar to Roberts, it is specified that

11. $$p_t^C = p_t^M + (y_t - y_t^N).$$

The above states that the ideal price "with cost" to adjustment is pegged along the same level as the rest of competition. In addition, if aggregate demand increases, output expands over its trended level and so the ideal price increases. Assume that all firms are identical as Roberts does. With p_t being the choice variable, it can be shown that

12. $$\pi_t = \frac{E_t \pi_{t+1} + \pi_{t-1}}{2} + \frac{\psi_t - \psi_t^N}{2}, \quad \pi = \frac{dp}{dt} \quad \& \quad \psi = \frac{dy}{dt}.$$

c. Variant of the EAPC and NKPC

Refer back to the AS curve in equation 9. Taking the log of each side and then taking the time derivative yield

13. $$\pi_t = \pi_t^e - (\mu_t - \lambda_t) - (\psi_t - \tau_t), \quad \mu = \frac{\Delta U}{U}, \quad \lambda = \frac{\Delta L}{L} \quad \& \quad \tau = \frac{\Delta T}{T}.$$

If there is "price adjustment cost", equation 12 is incorporated in equation 13 through the variable ψ. Further rearranging gives

14. $$\pi_t = \frac{2}{3}\frac{\left(E_t\pi_{t+1} + \pi_{t-1}\right)}{2} + \frac{\pi_t^e}{3} - \left(\frac{\mu_t - \lambda_t}{3}\right) - \left(\frac{\psi_t^N - \tau_t}{3}\right).$$

If one assumes adaptive expectations, past inflation can substitute for expected inflation. But this cannot be strictly applied in the NK setting. The reason is that π_t^e implicitly depends on $E_t\pi_{t+1}$ where the current information set includes prices catching up to target prices. In Rotemberg's framework, the target price is the price had there been no cost of adjustment. In Calvo's framework, it is the price signaled in the midst of staggered price adjustments. And in Taylor's framework, it is a function of wage, wage is a function of contracted wages, and a contracted wage is a function of real wages over the life (today up to the future expiration) of a contract. Another reason as Rudd and Whelan (2005) would argue is that substituting π_{t-1} for π_t^e ignores inertia.

An alternative and a purely NK approach is to proxy $E_t\pi_{t+1}$ for π_t^e but Fuhrer (1997) suggests "that the pure forward looking specification of prices is empirically unimportant" (Daniskova and Fidrmuc, 2011, page 101). Assume that π_t^e depends on past inflation and the expected future inflation, it may be specified that

15. $$\pi_t^e = \frac{E_t\pi_{t+1} + \pi_{t-1}}{2}.$$

Inserting the above into equation 14 and then simplifying gives

16. $$\pi_t = \frac{E_t\pi_{t+1} + \pi_{t-1}}{2} - \frac{1}{3}(\mu_t - \lambda_t) - \frac{1}{3}(\psi_t^N - \tau_t).$$

Looking at equations 13 and 16, the intuitive and empirical relationship between π and ψ-τ is ambiguous. Suppose that output accelerates and that the labor force grows constantly or is constant. In the case of acceleration coming from productivity, inflation will be lower; but in the case of acceleration coming from employment, inflation will be higher. This ambiguity is particularly relevant with economies with stable population growth. For simplification without loss of the main issue of interest, equations 13 and 16 are expressed as

17. $$\pi_t = \pi_t^e - a(\mu_t - \lambda_t).$$

18. $$\pi_t = \left(\frac{E_t\pi_{t+1} + \pi_{t-1}}{2}\right) - a(\mu_t - \lambda_t).$$

The above are variants of the conventional specifications EAPC and NKPC expressed in equations 1 and 3. This paper from this point refers to these as EAPC-2 and NKPC-2. Note the difference. Inflation is related with unemployment rate in EAPC and NKPC whereas inflation is related with the growth rate of unemployment net of the growth rate of employment in EAPC-2 and NKPC-2. Borrowing from Blanchard and Katz' (1997, page 53), "What matters to the unemployed is not how many of them there are, but how many of them there are in relation to the number of hires by firms." In addition, price is expressed in its dynamic state and unemployment in the static state in EAPC and NKPC. However, price and unemployment are both expressed in their dynamic states in the case of EAPC-2 and NKPC-2.

3. Empirical Models of EAPC, NKPC, EAPC-2 and NKPC-2

The stochastic equations for the EAPC, NKPC, EAPC-2 and NKPC-2 are

19. $\pi_t = b + c\pi_{t-1} - au_t + d[Country] + e[Crisis_t] + f_t,$
20. $\pi_t = b + c\pi_{t+1} - au_t + d[Country] + e[Crisis_t] + f_t,$
21. $\pi_t = b + c\pi_{t-1} - a(\mu_t - \lambda_t) + d[Country] + e[Crisis_t] + f_t$ &
22. $\pi_t = b + c\left(\frac{\pi_{t-1} + \pi_{t+1}}{2}\right) - a(\mu_t - \lambda_t) + d[Country] + e[Crisis_t] + f_t.$

The notations *a*, *b*, *c*, *d* and *e* are partial regression coefficients, and f_t is the error term assumed to be serially uncorrelated. As in standard assumption of adaptive expectation as in Ball (2000) and Ball and Mankiw (2002), past inflation or π_{t-1} proxies for π_t^e whenever applicable. As in McCallum (1976) or as in Gali and Gertler's (1999) assumption of rational expectations, the actual future inflation can proxy for the expected future inflation so that π_{t+1} proxies for $E\pi_{t+1}$ whenever applicable. The notation [*Country*] is a vector of fixed effect variables representing Hungary, the Czech Republic, Latvia, Lithuania or Estonia. If all fixed effect variables have value of zero, the country is Poland.

4. Data

This paper concentrates on Poland, Hungary and the Czech Republic or the CE-3, and Estonia, Latvia and Lithuania or the Baltic Tigers. The lumping of these economies is convenient. The first reason of convenience is geography. All are located in north and central Europe. Each is adjacent to at least one other. And four of six coast along the Baltic Sea. The second reason is shared history. All were common satellites of the former Soviet Union. All seceded from the Soviet rule and communism in 1989. Specifically, the Baltic Tigers seceded from a single revolution known as the Singing Revolution. In 1999, each of the CE-3 simultaneously joined the North Alliance Treaty Organization. In the European Union, Poland and Hungary applied for membership in 1994, the Baltic Tigers in 1995, and the Czech Republic in 1996.

It is concomitant that the third reason is economics. In the early 1990's each is classified as a Transition Economy. Each has its own currency and therefore monetary policy in the coverage of the study; that is from as early as 1998 to 2008. Each fulfilled the economic preconditions of joining the European Union in about the same time as each became full member in 2004. The levels of per capita income are close to each other. For example, I access the IMF (2011) and there are 182 countries whose data on GDP per capita from 1998 to 2008 (or part of the said years) is available. Ranking them from highest to lowest, it can be shown that The Czech Republic is 43rd, Hungary is 46th, Estonia is 47th, Poland is 52nd, Lithuania is 53rd and Latvia is 55th.

The data for the levels of price, unemployment and employment are taken from the International Labor Organization downloadable from laborsta.ilo.org. All raw data are annual. All employment and unemployment data are gathered from the Labor Force Survey. Inflation rate, unemployment rate, and the rates of change of unemployment and employment are then calculated from the downloaded numbers. All economies involved went through transition from communism to capitalism, and so it is understandable that all did not have the characteristics of a normal capitalistic economy immediately after 1989. Table 1 summarizes the coverage of the data. Accordingly, the first year that all growth rates are calculable for Hungary is 1993 with 22 percent inflation, for Estonia is 1992 with 1,060 percent inflation, for Latvia is 1992 with 957 percent inflation, and for Lithuania is 1995 with 40 percent inflation. The coverage of data testing begins when the economies become normal capitalistic economies and the assumption is that this begins when inflation reach 10 percent or less for the first time.

Table 1 – Summary of Coverage of Data

	Poland	Czech R.	Hungary	Estonia	Latvia	Lithuania
First employment data	1993	1993	1992	1989	1996	1994
Last employment data	2008	2008	2008	2008	2008	2008
First CPI data	1998	1990	1987	1991	1991	1991
Last CPI data	2008	2008	2008	2008	2008	2008
First complete rates	1999 (7%)	1994 (10%)	1993 (22%)	1992 (1,060%)	1992 (957%)	1995 (40%)
First =<10% inflation	1999 (7%)	1994 (10%)	2000 (10%)	1998 (8%)	1997 (8%)	1997 (9%)
Observations in EAPC	9	15	9	11	12	12
Observations in NKPC	8	14	8	10	11	11
Financial Crisis		1997, 1998		2008	2008	2008

Source of levels of employment and consumer price index: ILO

In the case of Poland, the first year when the data on levels is complete is 1998. The first period that rates are calculable and that inflation is 10 percent or less is from 1999, which leaves 10 observations. In the EA model, the lag inflation is proxy for the expected inflation, which leaves 9 observations. In the NK model, the lag and the forward inflation are proxy for the expected present and future inflation, which leaves 8 observations. For the rest, the first years when the data on levels is complete is 1993 for the Czech Republic, 1992 for Hungary, 1991 for Estonia, 1996 for Latvia and 1994 for Lithuania.The first period that rates are calculable and that inflation is 10 percent or less is 1994 for the Czech Republic leaving it 15 observations, 2000 for Hungary leaving it 9 observations, 1998 for Estonia leaving it 11 observations, and 1997 for Latvia and Lithuania living them with 12 observations each. In the EA model, the lag inflation is the proxy for the expected inflation, the inflation from the previous year is calculable, leaving each with the same number of observations. In the NK model, the lag and the forward inflation are proxy for the expected present and future inflation, leaving each 1 observation less. Finally, the value of the dummy variable is 1 for the Czech Republic in 1997 and 1998, and for all Baltic Tigers in 2008 representing financial crises periods. The value of the dummy variable for the rest is 0.

5. Results

The regression results are in Table 2 for the EAPC, Table 3 for the NKPC, Table 4 for the EAPC-2 and Table 5 for the NKPC-2. In conventional specifications, the EAPC captures the negative partial regression coefficient between inflation rate and unemployment rate more than the NKPC does. In the EAPC, the coefficient is negative in all and significant for the Czech Republic, Latvia and Lithuania, and also for the panel data. In the NKPC, the coefficient is negative in three of seven runs but significant for the Czech Republic only. In variant specifications, the EAPC-2 captures the negative partial regression coefficient between inflation and unemployment more than the NKPC-2 does. In the EAPC-2, the coefficient is negative in six of seven runs and significant for the Czech Republic, Hungary, and also for the panel data. In the NKPC-2, the coefficient is negative in five of seven runs but significant for Hungary only. In comparing the EA and the NK specifications, the results are more consistent with a priori relationship in the EA.

Table 2 – EAPC

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Constant	.04	.09***	.06	.04*	.09***	.05***	.07***
Inflation(t-1)	.65*	.23*	.37	.41*	.47***	.36***	.39***
Unemployment Rate	-.19	-.91**	-.35	-.21	-.59***	-.30**	-.33***
Financial Crisis		.04**		.04*	.06***	.06***	.05***
Czech							-.03***
Hungary							-.01
Estonia							-.02*
Latvia							-.00
Lithuania							-.02**
Observations	9	15	9	11	12	12	68
R^2	.46	.77	.23	.69	.93	.92	.74
F	2.6	12.5***	.9	5.3**	35.0***	28.9***	21.0***
White	5.37	5.26	5.74	4.36	6.23	3.49	20.28
Lagrange Multiplier	.14	.87	.10	.13	.89	.19	

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.

Table 3 – NKPC

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Constant	-.05	.11*	.12	.04	-.07	-.04	-.00
Inflation(t+1)	1.36	.09	.43	.24	.94***	.92**	.60***
Unemployment Rate	.30	-1.16*	-1.26	-.03	.6	.38	.11
Financial Crisis		.04*					.03**

Czech							.01
Hungary							.02
Estonia							.01
Latvia							.00
Lithuania							-.00
Observations	8	14	8	10	11	11	62
R^2	.39	.68	.22	.11	.71	.50	.49
F	1.6	7.2***	.7	.4	9.6***	4.0*	6.3***
White	6.78	6.97	7.50	2.57	4.45	4.46	36.01**
Lagrange Multiplier	.16	.07	.02	.00	.36	.66	

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.

Table 4 – EAPC-2

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Constant	.02	.02*	.05**	.02	.03*	.01	.02**
Inflation(t-1)	.51	.44***	.18	.48***	.28	.33***	.39***
%Δ of (Unemp-Emp)	.01	-.07*	-.18**	-.06	-.06	-.05	-.03**
Financial Crisis		.06**		.06**	.11*	.10***	.07***
Czech							.00
Hungary							.02**
Estonia							.00
Latvia							.01
Lithuania							-.01
Observations	9	15	9	11	12	12	68
R^2	.38	.70	.70	.72	.75	.86	.66
F	1.8	8.4***	6.9**	5.9**	7.9***	16.5***	15.4***
White	7.12	10.24	6.44	9.08	6.13	4.98	18.08
Lagrange Multiplier	.00	.59	.16	.07	2.51	.12	

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.

Table 5 – NKPC-2

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Constant	-.01	.01	.06*	.00	.00	.00	.02
Inflation [(t-1)+(t+1)]/2	1.33*	.61***	.09	.86**	.94***	.62***	.70***
%Δ of (Unemp-Emp)	.01	-.04	-.20*	-.03	.05	-.02	-.01
Financial Crisis		.05**					.03***
Czech							-.00
Hungary							.01
Estonia							-.00
Latvia							-.00
Lithuania							-.01
Observations	8	14	8	10	11	11	62
R^2	.69	.73	5.2	.57	.90	.88	.73
F	5.5*	9.0***	5.2**	4.6**	35.6***	30.4***	18.2***
White	6.54	12.27*	4.92	3.85	8.51	4.88	33.33*
Lagrange Multiplier	.13	2.60	.63	.23	.28	.55	

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.

Between the two NK runs, the variant results in negative partial regression coefficient more than the convention does with five of seven in the NKPC-2 versus three of seven in the NKPC. Both have one significant relationship; Hungary in the NKPC-2 and the Czech Republic in the NKPC. Also, the variant reflects a better fit where all seven *F*-statistics in the NKPC-2 are significant as compare to four in the NKPC. The regression results show that the better fit has to do with the different proxies for the expected inflation. That is the average of the lag and forward inflation predicts the present inflation better than the forward inflation only.

In the EA runs, the partial regression coefficient of inflation rate with respect to unemployment rate in the case of conventional specification is negative in all seven runs and significant for the Czech Republic, Latvia, Lithuania and also the panel data. On the other hand, the coefficient with respect to growth rate of unemployment net of growth rate of employment in the case of variant specification is negative in all but Poland and significant for the Czech Republic, Hungary and the panel data. Conventional specification has 5 of 7 significant overall regressions while the variant specification has 6 of 7. By close call, the EAPC outperforms the EAPC-2 in terms of providing evidence of the negative relationship between inflation and unemployment.

Note of the following additional observations. The first observation is that each coefficient of the constant in the EAPC is greater than that in the EAPC-2. This is shown in Table 6. For example, the coefficient of the constant for the Czech Republic is 0.09 in the EAPC and 0.02 in the EAPC-2. Also note that the average inflation in the coverage of regression run is generally in between; for example in the Czech Republic, the average inflation of 5 percent is between 0.09 and 0.02.

Table 6 – Intercepts in EAPC and EAPC-2

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Coefficient of the constant							
EAPC	.04	.09***	.06	.04*	.09***	.05***	.07***
EAPC-2	.02	.02*	.05**	.02	.03*	.01	.02**
Inflation							
Average	.04	.05	.06	.05	.06	.03	.05
Std. Dev.	.03	.04	.02	.03	.04	.04	.04

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.

As inflation is run with its lag value, a first order auto-regression within each run is implied in equations 19 and 21. That is, each contains

23. $\pi_t = b + c\pi_{t-1}$.

For inflation to be mean reverting, the necessary condition is $0<|c|<1$ and this condition holds in all runs. They also mean that that inflation is bounded to

24. $\pi = \dfrac{b}{1-c}$.

Table 7 shows the result of calculating the above, and this gives the second general observation. That is, inflation in the EAPC is bounded to be much greater than the average, while inflation in the EAPC-2 is bounded to approximately equal the average. Of particular example is the Czech Republic where the coefficients of the constant and lag inflation are significant. Inflation is bounded to 12 percent in the EAPC and 4 percent in the EAPC-2, while the average inflation in the coverage of data is 5 percent.

Table 7 – Bound of Inflation according to AR(1) in EAPC and EAPC-2

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Coefficient of the constant							
EAPC	.04	.09***	.06	.04*	.09***	.05***	.07***
EAPC-2	.02	.02*	.05**	.02	.03*	.01	.02**
Coefficient of lag inflation							
EAPC	.65*	.23*	.37	.41*	.47***	.36***	.39***
EAPC-2	.51	.44***	.18	.48***	.28	.33***	.39***
Inflation bound							
EAPC	.11	.12	.10	.07	.17	.08	.11
EAPC-2	.04	.04	.06	.04	.04	.01	.03
Inflation							
Average	.04	.05	.06	.05	.06	.03	.05
Std. Dev.	.03	.04	.02	.03	.04	.04	.04

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.

The third observation has to do with the implied long run relationship between inflation and unemployment. Equations 19 and 21 imply that the short run relationship between inflation and unemployment is measured by the coefficient *a*. The standard view is that in the long run, expected inflation catch up with actual inflation; hence $\pi=\pi_t \forall t$. Hence, the long run versions of equations 19 and 21 are

25. $$\pi=\frac{a}{1-c}u \quad \& \quad \pi=\frac{a}{1-c}(\mu-\lambda).$$

Shown in Table 8, the inflation is more responsive to unemployment in all case. Put differently, the PC is more Keynesian in the short run and is more Neoclassical in the long run. For example, Lithuania in the EAPC, a decrease of unemployment rate say from 5 percent to 4 percent pressures inflation rate to increase by 0.3 percent in the short run and increase by 0.51 percent in the long run. Another example is the Czech Republic in the EAPC-2. A percentage edge in the growth of level of employment over the growth of level of unemployment pressures inflation rate to increase by 0.07 percent in the short run and increase by 0.13 percent in the long run.

The existence of the natural rate of unemployment is debatable (Stiglitz, 1997). But assume it exists. The fourth observation is on the implied natural rate of unemployment given the EAPC. Given

26. $\pi_t = c\pi_{t-1} - a(u_t - u^N) \quad \rightarrow \quad \pi_t = au^N + c\pi_{t-1} - au_t.$

Juxtaposing equations 19 and 26, the constant *b* from equation 19 and the constant au^N from equation 26 are implied counterparts. Setting the two equal and then solving for u^N gives

27. $u^N = b / a.$

Table 9 shows the implied natural rate of employment. The implied natural rates are far above the average actual unemployment rate within the coverage of the data. For example, consider the results for Lithuania. The implied natural rate of unemployment is 17 percent. The average unemployment rate in the coverage of the data is 11 percent. Of the 12 observations, the actual rate of unemployment is greater than the implied rate only once, but is less than in 11 of 12 observations. Either the natural rate of unemployment does not exist, time varying or not captured because the relationship between inflation and unemployment rate is ambiguous.

Table 8 – Long Run Relationship between Inflation and Unemployment

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
EAPC							
Coefficient of π_{t-1}	.65*	.23*	.37	.41*	.47***	.36***	.39***
Short run coefficient	-.19	-.91**	-.35	-.21	-.59***	-.30**	-.33**
Implied long run coefficient	-.54	-1.18	-.56	-.38	-1.11	-.51	-.54
EAPC-2							
Coefficient of π_{t-1}	.51	.44***	.18	.48***	.28	.33***	.39***
Short run coefficient	.01	-.07*	-.18**	-.06	-.06	-.05	-.03**
Implied long run coefficient	.02	-.13	-.22	-.12	-.08	-.07	-.05

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.

Table 9 – Implied Natural rate of Unemployment from the EAPC

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Coefficient of the constant (b)	.04	.09***	.06	.04*	.09***	.05***	.07***
Coefficient of unemployment (a)	.19	.91**	.35	.21	.59***	.30**	.33**
Implied natural rate of	.21	.10	.17	.19	.15	.17	.21

unemployment							
Average unemployment rate	.16	.06	.07	.09	.11	.11	.10
Greater-less than implied	0 - 9	0 - 15	0 - 9	0 - 11	1 - 11	1 - 11	0 - 68

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.

6. Conculusion

In convention, the relationship between price and unemployment is expressed in terms of the PC where the rate of change of price through time or inflation is related with the rate of unemployment at a time; that is price is dynamic and unemployment is static. In variant specification, the relationship between price and unemployment are expressed both in their dynamic states. In convention, the transformation from the AS curve to the PC curve is ambiguous. For example, both price and output are levels without limits in the AS curve whereas price as represented by inflation is rate without limit and unemployment as represented by its rate is limited to 100 percent. In the variant specification, the rates of change of price (inflation), unemployment and employment just like in the AS are without upper limits.

Individual and combined regression tests are conducted on the CE-3 and the Baltic Tigers. Between the Neoclassical expectations augmented (EA) and the NK specifications, the EA is better able to track the negative relationship between inflation and unemployment. Between the NK specifications, the variant specification is more able to result in overall significance than the conventional specification is able. But the significance is probably more to do with the relationship between present inflation and the average lag and forward inflations, and less to do with the relationship between inflation and growth rate of unemployment net of growth rate of employment.

Between the EA specifications, the conventional specification tracks a negative relationship between inflation and unemployment in all runs with four of seven being significant, while the variant specification tracks a negative relationship in six of seven runs with three of seven being significant. Some observations must be noted. One is that inflation is mean reverting and the mean inflation in the variant specification is more sensible than in the conventional specification owing that the former is closer to the actual average inflation in the coverage of the data. Another is that the PC is steeper in long run than in the short run and this finding is consistent with standard theory. Finally, the implied natural rate of unemployment in conventional specification is far greater than the average unemployment rate in the coverage of the data.

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Appendix 1 – The Price of Oil as a Supply Side Shock

The insertion of the dummy variable representing financial crises years is necessary to take into account of exogenous shifts of the AS and PC curves. Alternatively, this section shows the results if one uses the rate of increase of the domestic price of oil to proxy for the exogenous shifts of the AS and PC curves. The US dollar price of oil is the price per barrel which is downloaded from www.indexmundi.com. The price is converted to domestic price using the exchange rates taken from the Bank of Estonia (or the central bank of Estonia) through http://statistika.eestipank.ee/?lng=en#treeMenu/VALUUTA. The rate of increase of the domestic price of oil is insignificant except in the rare result for Poland in the EAPC and EAPC-2 and Estonia in the NKPC. However, all financial crisis dummy is positive and significant in all runs in the main text.

Table A1-1 - EAPC

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Constant	.03	.08	.07	.06*	-.08*	.06**	.08***
Inflation(t-1)	.68**	.34	.32	.52*	.85**	.63**	.60***
Unemployment Rate	-.19	-.76	-.41	-.41	-.63**	-.41**	-.42***
Oil	.07**	-.01	.01	.01	.02	.01	.01
Czech							-.03***
Hungary							-.03**
Estonia							-.02*
Latvia							-.01
Lithuania							.02*
Observations	9	11	9	11	11	11	62
R^2	.80	.34	.24	.49	.82	.70	.59
F	6.6***	1.2	.50	2.2	10.3***	5.6**	9.6***

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.

Table A1-2 – NKPC

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Constant	-.03	.01	.13	-.01	.01	.01	.02
Inflation(t+1)	1.01	.28	.35	.60	.55	.45	.50***
Unemployment Rate	.22	.22	-1.35	.30	-.01	-.01	.03
Oil	.03	-.05	.01	-.04*	-.00	.02	-.02
Czech							.00
Hungary							.02
Estonia							.00
Latvia							-.00
Lithuania							-.00
Observations	8	10	8	10	10	10	56
R^2	.44	.16	.23	.46	.78	.56	.45

F	1.0	.4	.4	1.7	7.4***	2.7*	4.8***

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.

Table A1-3 – EAPC-2

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Constant	.01	.03	.06**	.03	.00	.01	.01
Inflation(t-1)	.77*	.18	.13	.43	1.06*	.73*	.61***
%Δ of (Unemp-Emp)	-.04	.03	-.19**	.01	.07	.02	.01
Oil	.08**	-.03	.01	-.01	.02	.02	.01
Czech							.00
Hungary							.01
Estonia							.01
Latvia							.01
Lithuania							.00
Observations	9	11	9	11	11	11	62
R^2	.74	.24	.73	.26	.68	.44	.43
F	4.7**	.8	4.6**	.9	5.0**	1.9	5.0***

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.

Table A1-4 – NKPC-2

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Constant	-.02	.03	.08*	.01	.00	.00	.01
Inflation [(t-1)+(t+1)]/2	1.28**	.29	-.28	.8**	.95***	.79***	.86***
%Δ of (Unemp-Emp)	.00	.05	-.24*	-.01	.03	-.01	.00
Oil	.05	-.04	.02	-.02	.01	-.01	-.01
Czech							-.00
Hungary							.00
Estonia							-.00
Latvia							-.00
Lithuania							-.01
Observations	8	10	8	10	10	10	56
R^2	.85	.38	.74	.62	.88	.82	.63
F	7.6***	1.2	3.8**	3.4*	16.0***	9.1***	9.9***

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.

Appendix 2 – Running the Data including Hyperinflationary Transition Periods

The coverage of data testing begins when the economies become normal capitalistic economies and the assumption is that this begins when inflation reach 10 percent or less for the first time. The succeeding tables show the regression results when all data are included including hyperinflationary periods. The regression results for Poland, the Czech Republic and Latvia are not shown given that the data used in the main text is the same as here and hence without transition data. In the variant specification, the relationship between inflation and unemployment is never significant. In conventional specification, the same is significant in two of four runs for each the EAPC and the NKPC, but all with positive signs which is counter intuitive.

Table A2-1 – EAPC

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Constant			-.08*	.17		-.02	-.06
Inflation(t-1)			.48***	.08***		.17***	.09***
Unemployment Rate			1.72**	-.81		.52	.49*
Financial Crisis				-.03		.09	.06
Czech							.05
Hungary							.12***
Estonia							.08**
Latvia							.04
Lithuania							.06*
Observations			17	16		15	84
R^2			.84	.80		.86	.72
F			37.5***	15.9***		23.3***	24.2***

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.

Table A2-2 – NKPC

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Constant			-.05	-.11		-.13***	-.10**
Inflation(t+1)			.62**	1.90***		1.67***	1.57***
Unemployment Rate			1.33	.66		.95***	.54**
Financial Crisis							.02
Czech							.04
Hungary							-.00
Estonia							.04
Latvia							-.00
Lithuania							.03
Observations			16	15		14	78

R^2	.81	.96		.97	.89
F	27.2***	149.8***		202.0***	70.1***

Notations: * if P-value < .1; ** if P-value < .05: *** if P-value < .01.

Table A2-3 – EAPC-2

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Constant			.01	.10***		.00	.04
Inflation(t-1)			.85***	.06***		.54***	.08***
%Δ of (Unemp-Emp)			.00	.27		-.04	.05
Financial Crisis				-.06		.09**	.03
Czech							.01
Hungary							.08**
Estonia							.06*
Latvia							.02
Lithuania							.03
Observations			16	16		14	82
R^2			.79	.83		.97	.69
F			23.8***	19.2***		103.9***	20.3***

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.

Table A2-4 – NKPC-2

	Poland	Czech	Hungary	Estonia	Latvia	Lithuania	Panel Data
Constant			.00	.10***		-.00	.03
Inflation [(t-1)+(t+1)]/2			.98***	.12***		.85***	.15***
%Δ of (Unemp-Emp)			.01	.25		-.00	.04
Financial Crisis							.03
Czech							.01
Hungary							.08**
Estonia							.06*
Latvia							.01
Lithuania							.03
Observations			15	15		13	76
R^2			.86	.84		.98	.72
F			36.0***	31.0***		217.4***	21.9

Notations: * if *P*-value < .1; ** if *P*-value < .05: *** if *P*-value < .01.